Richard Geller PRIZE

L. T. Sun

Institute of Modern Physics, CAS
Acknowledgements

Richard Geller PRIZE, really great prize for those young scientists Working on ECRISs

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Acknowledgements

- Thank you, PANTECHNIK Company for your support!
- Thank you, prize committee!
- Success belongs to my group!
- Thanks to all colleagues who ever helped us!

… …
Acknowledgements

The only group photo taken with Prof. Geller
Taken on 16th September, 2005, GANIL, Caen, France
I am happy to be one member of this big family

Challenges!
Competitions!
& Cooperations!
High Charge State All Permanent Magnet ECRIS Operated on 320 kV HV Platform

L. T. Sun

Institute of Modern Physics, CAS
Outline

- Introduction to LAPECRR2
- Ion Source Commissioning
- Metallic ion beam production (preliminary)
- 320 kV HV platform and LAPECRR2 operation status
Introduction

LECR3: 5~25 keV/q
SFC (K=69): 1~10 MeV/u
SFC+SSC or CSR: higher energy

HIRFL

K=450
K=69

12.1 Tm
CSRm
1.1GeV/u—C^{6+}
2.8GeV—p

9.4 Tm
CSRe
500MeV/u—U^{92+}
Motivation

Electricity free, high pressure cooling water free, simplicity, low running expense, long-term running stability.

Used on IMP 320 kV HV platform to produce stable intense medium charge state ion beams such as: hundreds of \( euA \) \( Ar^{8+} \), \( C^{4+} \); high charge state ion beams, such as gaseous ion beams \( Ar^{14+} \), \( Kr^{20+} \), \( Xe^{27+} \) etc., and also metallic ion beams \( Ca^{14+} \), \( Pb^{27+} \)...

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Conceptual Design

- High B, high frequency modes: $\omega_{rf} = 14.5$ GHz
- $|B|$ contour closed at 2 $B_{ecr}$:
  - $B_{inj} \sim 1.3$ T (2.1 T with iron plug)
  - $B_{min} \sim 0.42$ T
  - $B_{ext} \sim 1.1$ T
  - $P_{rf} \sim 1.0$ kW

Chamber ID as large as possible within reasonable cost and fabrication possibility
Schematic Design

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Magnet Fabrication

Blank cutting

Gluing after Being magnetized

Totally 648 pieces in axial magnet rings, 216 pieces in hexapole magnet, precisely glued

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## Typical Parameters

### Comparison of the parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>LAPECR2</th>
<th>LECR2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial Mirror Peak (T)</td>
<td>1.28 (2.1), 1.07</td>
<td>1.5, 1.1</td>
</tr>
<tr>
<td>$B_{\text{min}}$ (T)</td>
<td>0.42</td>
<td>0.39</td>
</tr>
<tr>
<td>$B_{\text{rad}}$ (T)</td>
<td>1.21</td>
<td>1.0</td>
</tr>
<tr>
<td>Hexapole Material (NdFeB)</td>
<td>36-segmented N45M</td>
<td>24-segmented N42</td>
</tr>
<tr>
<td>RF Frequency (GHz)</td>
<td>14.5</td>
<td>14.5</td>
</tr>
<tr>
<td>Feeding Mode</td>
<td>Off-axis Direct Feeding</td>
<td>Coaxial Feeding</td>
</tr>
<tr>
<td>$L_{\text{mirror}}$ (mm)</td>
<td>255</td>
<td>300</td>
</tr>
<tr>
<td>$L_{\text{ecr}}$ (mm)</td>
<td>100</td>
<td>86</td>
</tr>
<tr>
<td>Plasma Chamber ID (mm)</td>
<td>67</td>
<td>70</td>
</tr>
<tr>
<td>Chamber Material</td>
<td>316L SS</td>
<td>316 SS</td>
</tr>
</tbody>
</table>
Problems and Solutions

700 l/s pumping

Injection

Extraction

Modified to maximize vacuum evacuation.

Modified to minimize stray field damage and enhance vacuum pumping speed.

Base Vacuum:
- Injection: $2.0 \times 10^{-7}$ mbar
- Extraction: $4.0 \times 10^{-8}$ mbar
- Beam line: $1.0 \times 10^{-8}$ mbar

Great efforts have been made to enhance RF power feeding efficiency and lower reversed power.

Careful handling of the extraction system to increase max. extraction HV and improve operation stability.

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For rf power under 1.1 kW, the ratio of reversed rf power is normally less than 10%.
Higher extraction HV can help obtain more medium charge state ion beam, but for heavier higher charge state ion beams, the effect is not so obvious (high charge state ion beams have lower emittance…)

Two modes:

\[ j = \frac{4\varepsilon_0}{9} \sqrt{\frac{2Qe}{M}} \frac{U^{3/2}}{d^2} \]

or

\[ j = n_i e \sqrt{\left(\frac{kT_e}{M}\right)} \]
Commission Results (3)

Ion Beam Intensity (eμA) vs Charge State Q for xenon ion beams. The graph shows data for different systems:
- LAPECR2 (14.5 GHz)
- SOPHIE (13.5 GHz)
- LECR2 (14.5 GHz)
- Caprice (14.5 GHz)

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Metallic Ion Beam (preliminary)

With $P_{rf} = 350$ W, HV=15kV,
Typical results of bismuth ion beams:

$24 \, \mu A \, Bi^{21+}$, $17 \, \mu A \, Bi^{28+}$, $5 \, \mu A \, Bi^{31+}$...
320 kV HV Platform (1)

Terminal No. 4
Atomic Physics II

Terminal No. 3
Material Physics

Terminal No. 2
Atomic Physics I

Terminal No. 1
HCl Physics

Terminal 5:
Biophysics and astrophysics

320 kV HV platform
320 kV HV Platform (2)

Water resistor columns
HV platform shielding electrode
LAPECR2
Insulator columns

390 kV HV without ion beam has been successfully tested
320 kV HV Platform (3)

Energy Range:
5 keV/q~340 keV/q

Under service for many physical research studies

more than 11,500 hrs for the commissioning of the HV platform and several physical experiments which covered 9,000 hrs. The operation time with the platform HV biased is up to about 5,000 hrs. The highest on-line operation HV applied is 320 kV.
Thanks for your attention!